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Onodera

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(54) **CIRCUIT MODULE INCLUDING A SPLITTER AND A MOUNTING SUBSTRATE**

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(51) **Int. Cl.**

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H03H 9/05	(2006.01)
H05K 1/02	(2006.01)
H05K 1/11	(2006.01)

(52) **U.S. Cl.**

CPC ***H01P 5/12*** (2013.01); ***H03H 9/0566*** (2013.01); ***H04M 1/0202*** (2013.01); ***H05K 1/0227*** (2013.01); ***H05K 1/0233*** (2013.01); *H05K 1/0243* (2013.01); *H05K 1/113* (2013.01); *H05K2201/09618* (2013.01); *H05K 2201/1006* (2013.01)

(58) **Field of Classification Search**

CPC ... H04M 1/0202; H05K 1/0243; H05K 1/113; H05K 2201/09618

USPC 455/550.1; 333/101, 132, 134, 238

See application file for complete search history.

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(57) **ABSTRACT**

In a circuit module, even if a transmission signal output from a transmission electrode of a mounting substrate to a transmission terminal of a splitter leaks into a ground electrode, the transmission signal that has leaked into the ground electrode flows into via conductors that are connected along an edge portion of the ground electrode close to the transmission electrode and connected to a ground line of a motherboard. Therefore, the transmission signal that has been output from the transmission electrode and leaked into the ground electrode is prevented from traveling along an edge portion of the ground electrode toward a reception electrode side. Thus, characteristics of isolation between the transmission electrode and the reception electrode provided on the mounting substrate on which the splitter is mounted are improved.

21 Claims, 4 Drawing Sheets

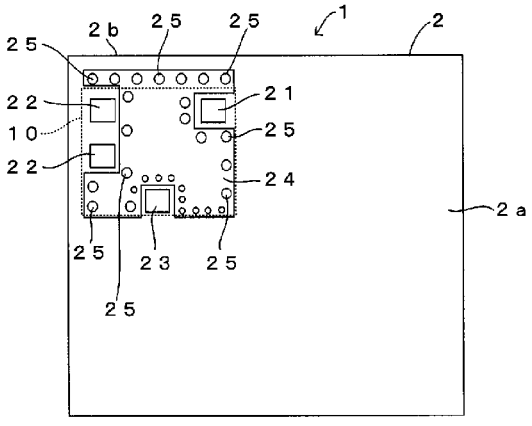

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FIG. 1

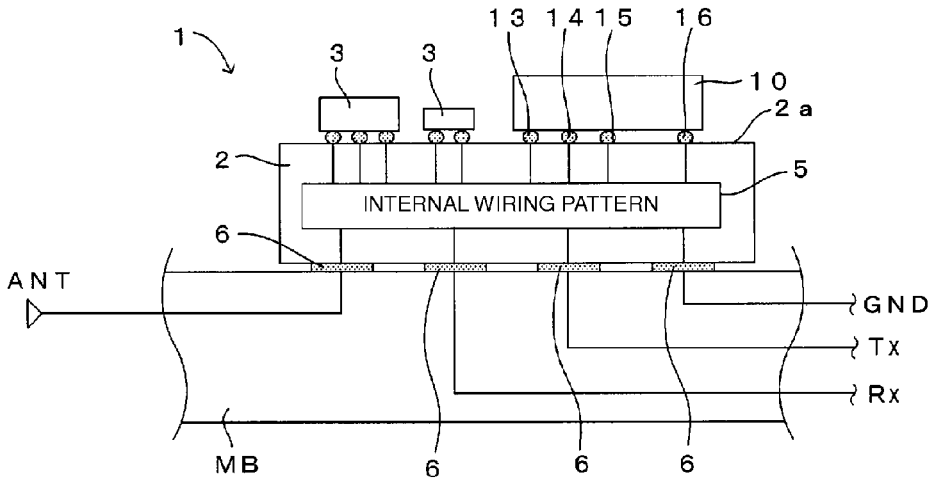

1
3
3
13 14 15 16
10
2a
2
5
INTERNAL WIRING PATTERN
6
ANT
GND
Tx
Rx
MB
6
6
6

FIG. 2

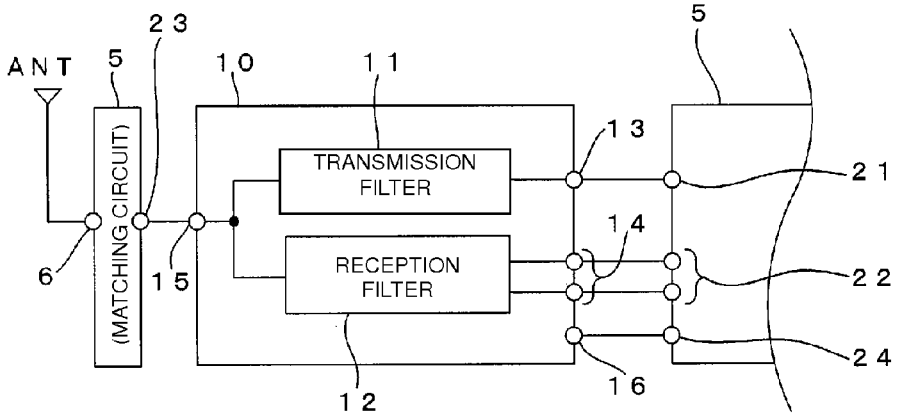

ANT
5
23
10
11
5
(MATCHING CIRCUIT)
TRANSMISSION FILTER
13
21
14
RECEPTION FILTER
22
6
15
24
12
16

FIG. 3

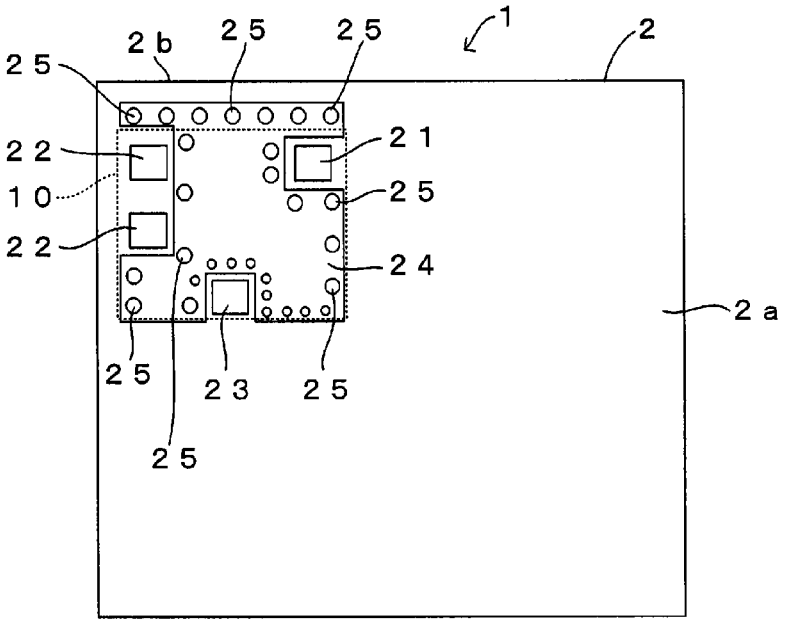

1
2
2 b
2 5
2 5
2 5
2 2
1 0
2 2
2 1
2 5
2 4
2 a
2 5
2 3
2 5
2 5

FIG. 4

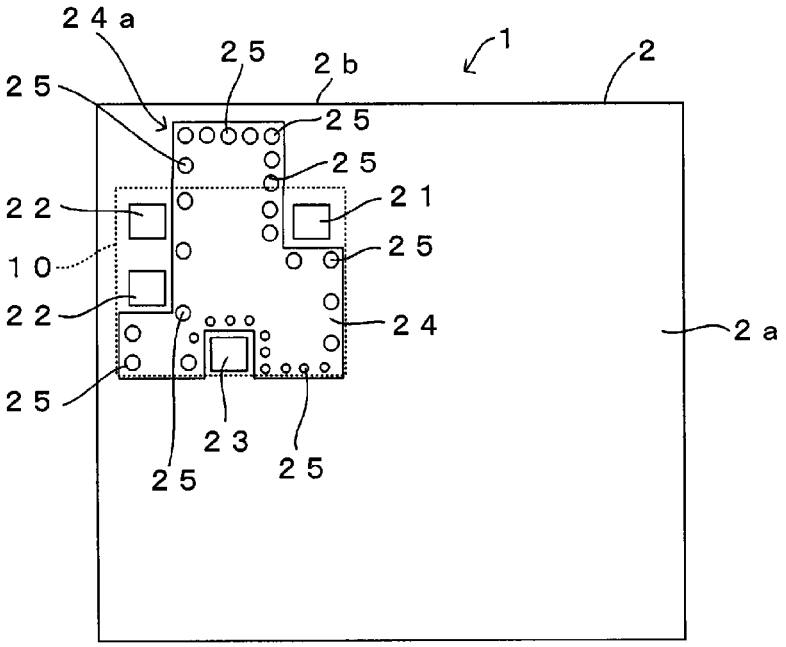
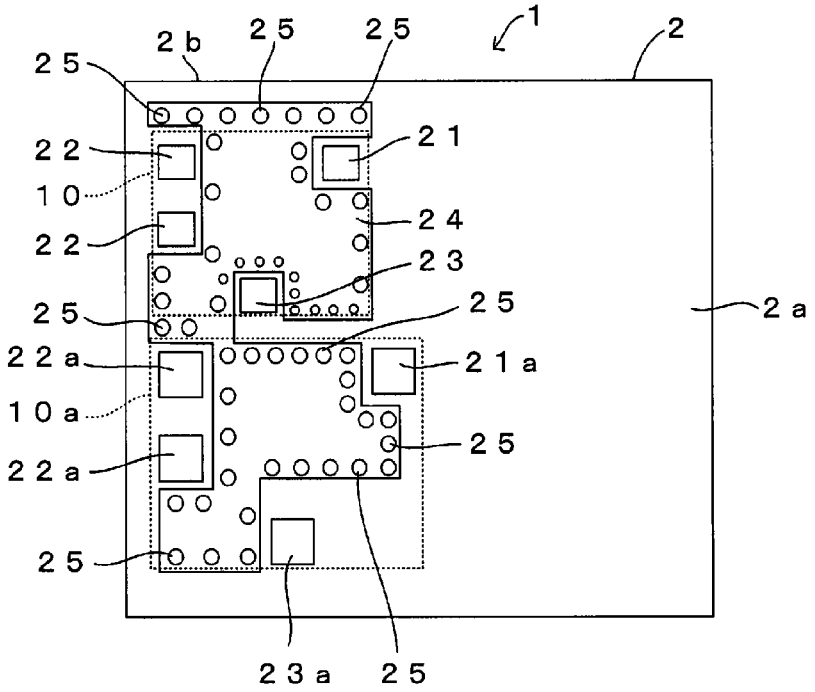

2 4 a
1
2
2 5
2 b
2 5
2 5
2 5
2 2
2 1
1 0
2 5
2 2
2 4
2 a
2 5
2 3
2 5
2 5

FIG. 5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2 5
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2 2
2 1
2 4
2 3
2 5
2 5
2 a
2 2 a
1 0 a
2 2 a
2 1 a
2 5
2 5
2 3 a
2 5

FIG. 6

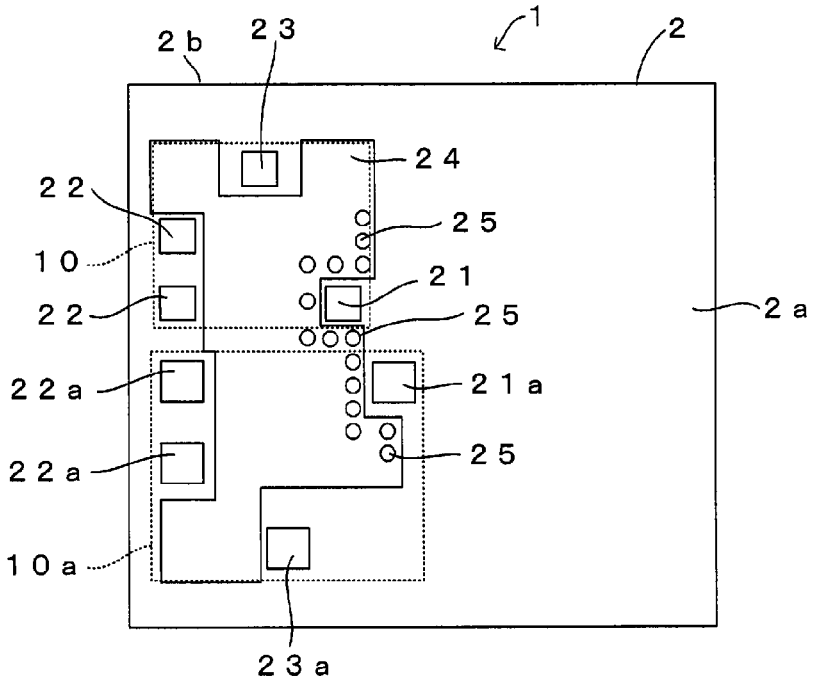
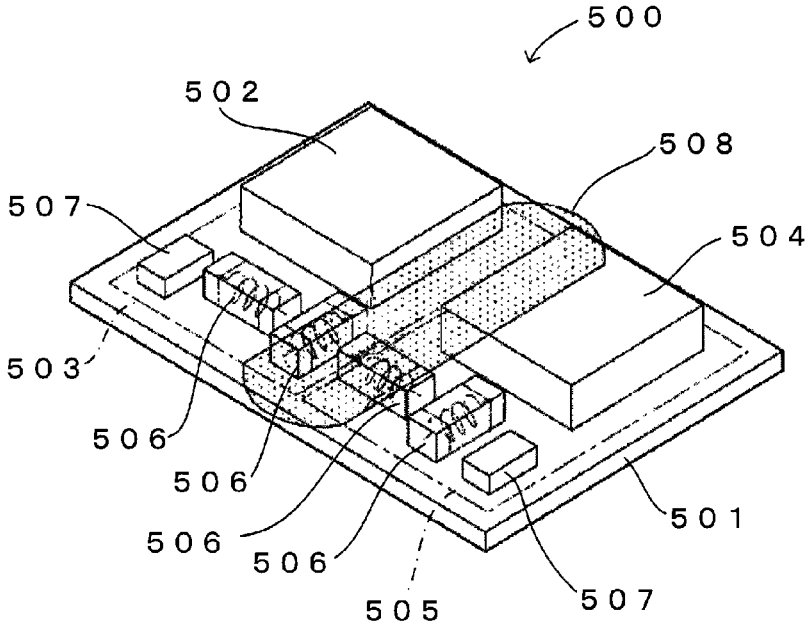

1
2
2 b
2 3
2 4
2 2
2 5
1 0
2 1
2 2
2 5
2 a
2 2 a
2 1 a
2 2 a
2 5
1 0 a
2 3 a

FIG. 7
PRIOR ART



CIRCUIT MODULE INCLUDING A SPLITTER AND A MOUNTING SUBSTRATE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to circuit modules that include a splitter including a transmission filter and a reception filter with different pass bands from each other.

2. Description of the Related Art

In recent years, mobile communication terminals such as cellular phones and mobile information terminals that support communication using a plurality of communication standards such as the global system for mobile communications (GSM) standard and the code division multiple access (CDMA) standard have rapidly become widespread, and in such mobile communication terminals, transmission and reception of signals of different frequency bands is performed using a common antenna. Therefore, there have been growing demands for there to be further increases in the performance of and reductions in the size of front end modules (circuit modules) such as antenna switches including a splitter (duplexer) that separates a transmission signal and a reception signal having different frequencies from each other.

For example, as illustrated in FIG. **7**, a splitter **500**, which has a reduced size and increased performance as a result of having first and second filter units **503** and **505** having different signal frequency bands arranged close to each other in such a manner that the characteristics of the filter units **503** and **505** are not degraded, is mounted on a mounting substrate to be included in a circuit module, and as a result, the circuit module can be reduced in size and increased in performance. The splitter **500** of the related art illustrated in FIG. **7** includes the first filter unit **503**, which includes a surface acoustic wave (SAW) filter device **502**, and the second filter unit **505**, which includes a SAW filter device **504**, on a mounting surface of a base substrate **501** composed of a resin, a ceramic or a polymer material, such as a printed substrate, an LTCC substrate, an alumina-based substrate, a glass substrate or a composite material substrate, and the first and second filter units **503** and **505** are each provided with passive devices such as chip inductors **506** and chip capacitors **507** that serve as peripheral circuit devices that complement the electrical characteristics of the SAW filter devices **502** and **504**.

In order to suppress electromagnetic interference between the inductor devices and prevent signal interference between the filter units **503** and **505**, the chip inductors **506**, which are arranged so as to be adjacent to each other in a boundary portion **508** between the first filter unit **503** and the second filter unit **505**, are arranged on the base substrate **501** such that their magnetic flux directions are substantially orthogonal to each other. By adopting this configuration, even though the filter units **503** and **505** are arranged close to each other, signal interference between the first and second filter units **503** and **505** is prevented and changes in the characteristics of the filter units **503** and **505** are reduced.

The splitter **500** of the related art, for which a reduction in size and an increase in performance have been achieved in this way, is mounted on a mounting substrate and the first and second filter units **503** and **505** of the splitter **500** are respectively utilized as a transmission filter and a reception filter and thereby a circuit module such as an antenna switch is formed.

In addition, the splitter **500** has a transmission terminal for allowing input of a transmission signal from the mounting substrate side to the transmission filter, a reception terminal for allowing output of a reception signal from the reception filter to the mounting substrate side, an antenna terminal (common terminal) that is connected to the output side of the transmission filter and the input side of the reception filter, and a ground terminal. The mounting substrate is provided with a transmission electrode and a reception electrode, which are respectively connected to the transmission terminal and the reception terminal of the splitter **500**. Then, a transmission signal is output via the transmission terminal to the transmission filter included in the splitter **500** from the transmission electrode of the mounting substrate and the transmission signal input to the transmission filter is subjected to predetermined filter processing and is then output from the antenna terminal of the splitter **500**. In addition, a reception signal is input to the reception filter included in the splitter **500** from the antenna terminal and the reception signal input to the reception filter is subjected to predetermined filter processing and is then output to the mounting substrate side via the reception electrode from the reception terminal of the splitter **500**.

There is a risk of a transmission signal, which has been output to the transmission terminal of the splitter **500** from the transmission electrode of the mounting substrate in order to input a transmission signal to the transmission filter, leaking toward the reception electrode, which is provided on the mounting substrate and is for allowing input of a reception signal, and interfering with a reception signal input from the antenna terminal and output to the reception electrode of the mounting substrate from the reception terminal via the reception filter. Therefore, in general, in order to prevent a transmission signal output to the transmission terminal of the splitter **500** from the transmission electrode of the mounting substrate from interfering with a reception signal input from the antenna terminal and output to the reception electrode of the mounting substrate from the reception terminal of the splitter **500** via the reception filter, a ground electrode, which is connected to the ground terminal of the splitter **500**, is provided between the transmission electrode and the reception electrode on the mounting substrate.

In recent years, size reduction of mobile communication terminals has been rapidly progressing and there is a demand for further size reduction of a circuit module mounted in a mobile communication device and of the splitter **500** mounted in the circuit module. However, if the splitter **500** is further reduced in size, the spaces between the transmission terminal, which is for allowing input to the transmission filter, and the reception terminal, which is for allowing output from the reception filter, of the splitter **500** become extremely small, and therefore, even though the ground electrode, which is connected to the ground terminal of the splitter **500**, is provided between the transmission electrode and the reception electrode provided on the mounting substrate on which the splitter **500** is mounted, there is a risk of a transmission signal output to the transmission terminal of the splitter **500** from the transmission electrode of the mounting substrate leaking into the ground electrode and of the transmission signal that has leaked into the ground electrode traveling along an edge portion of the ground electrode toward the reception electrode side and interfering with a reception signal output to the reception electrode of the mounting substrate from the reception terminal of the splitter **500** via the reception filter. This is an obstacle to size reduction of the splitter **500**.

SUMMARY OF THE INVENTION

In view of the above, preferred embodiments of the present invention provide a technology in which characteristics of isolation between a transmission electrode and a reception

electrode are improved, the transmission electrode and the reception electrode being provided on a mounting substrate on which a splitter is mounted.

A circuit module according to a preferred embodiment of the present invention includes a splitter including a transmission filter and a reception filter with different pass bands from each other, and a mounting substrate on which the splitter is mounted. The splitter includes a transmission terminal to allow input to the transmission filter, a reception terminal to allow output from the reception filter and a ground terminal. The mounting substrate is provided with a transmission electrode that is connected to the transmission terminal, a reception electrode that is connected to the reception terminal and a ground electrode that is arranged between the transmission electrode and the reception electrode and is connected to the ground terminal. A plurality of via conductors are connected to the ground electrode along an edge portion of the ground electrode that is close to the transmission electrode when viewed in plan.

In addition, it is preferable that the plurality of via conductors be connected to the ground electrode along edge portions of the ground electrode from an edge portion of the ground electrode close to the transmission electrode to an edge portion of the ground electrode close to the reception electrode when viewed in plan. With this configuration, a transmission signal that has been output from the transmission electrode and leaked into the ground electrode more efficiently flows into the plurality of via conductors connected along edge portions of the ground electrode and therefore the transmission signal that has leaked into the ground electrode is more efficiently prevented from traveling along an edge portion of the ground electrode toward the reception electrode side, and therefore the characteristics of isolation of the transmission electrode and the reception electrode from each other is greatly improved, the transmission electrode and the reception electrode being provided on the mounting substrate on which the splitter is mounted.

In addition, the transmission electrode and the reception electrode may be provided adjacent to or in a vicinity of an edge of a mounting surface of the mounting substrate and the ground electrode may be provided between that edge and the transmission electrode when viewed in plan. With this configuration, the circuit module is reduced in size by arranging the splitter close to an edge of the mounting substrate. In addition, since the ground electrode is provided between an edge of the mounting substrate and the transmission electrode when viewed in plan, a transmission signal that has been output from the transmission electrode and has leaked into the ground electrode flows into the plurality of via conductors connected along the edge portions of the ground electrode provided between the edge of the mounting substrate and the transmission electrode, and the transmission signal that has leaked into the ground electrode is prevented from traveling along an edge portion of the ground electrode toward the reception electrode side, and therefore the characteristics of isolation of the transmission electrode and the reception electrode from each other are greatly improved, the transmission electrode and the reception electrode being provided on the mounting substrate.

In addition, the ground electrode may be provided across a plurality of layers in the mounting substrate and individual portions of the ground electrode may be connected to each other with the via conductors. With this configuration, a transmission signal that has been output from the transmission electrode and leaked into the ground electrode more efficiently flows into the plurality of via conductors connected along edge portions of the ground electrode and therefore the transmission signal that has leaked into the ground electrode is more efficiently prevented from traveling along an edge portion of the ground electrode toward the reception electrode side. Therefore, the characteristics of isolation of the transmission electrode and the reception electrode from each other are further improved, the transmission electrode and the reception electrode being provided on the mounting substrate on which the splitter is mounted.

In addition, it is preferable that the ground electrode includes a first extended portion that extends toward an area outside of the splitter when viewed in plan. With this configuration, the distance from the edge portion of the ground electrode near to the transmission electrode to the edge portion of the ground electrode near to the reception electrode along the edge portions of the ground electrode becomes longer, and therefore a transmission signal that has been output from the transmission electrode and leaked into the ground electrode is prevented from traveling along an edge portion of the ground electrode toward the reception electrode side with certainty.

In addition, the ground electrode may further include a second extended portion that extends from an end portion of the first extended portion in at least one of a direction toward the transmission electrode and a direction toward the reception electrode. With this configuration, the distance from the edge portion of the ground electrode near to the transmission electrode to the edge portion of the ground electrode near to the reception electrode along the edge portions of the ground electrode becomes even longer, and therefore a transmission signal that has been output from the transmission electrode and leaked into the ground electrode is prevented from traveling along an edge portion of the ground electrode toward the reception electrode side with even more certainty.

In addition, the ground electrode may surround at least the transmission electrode when viewed in plan. With this configuration, the edge portion of the ground electrode surrounding the transmission electrode and the edge portion of the ground electrode near to the reception electrode are not connected to each other and therefore a transmission signal that has leaked into the ground electrode is prevented from traveling along an edge portion of the ground electrode toward the reception electrode side with certainty.

In addition, at least one of the transmission electrode and the reception electrode may be a rectangular or substantially rectangular land located on the mounting surface of the mounting substrate and the ground electrode may surround at least three sides of the rectangular or substantially rectangular periphery of the transmission electrode or the reception electrode when viewed in plan (Claim **8**). With this configuration, the distance from the edge portion of the ground electrode near to the transmission electrode to the edge portion of the ground electrode near to the reception electrode along the edge portions of the ground electrode becomes longer, and therefore a transmission signal that has leaked into the ground electrode is efficiently prevented from traveling along an edge portion of the ground electrode toward the reception electrode side.

In addition, the splitter may further include a common terminal that is connected to an output side of the transmission filter and an input side of the reception filter, the transmission electrode, the reception electrode, and a common electrode, which is connected to the common terminal, may be rectangular or substantially rectangular lands on the mounting surface of the mounting substrate, and the ground electrode may surround at least three sides of the transmission electrode, the reception electrode and the common electrode when viewed in plan. With this configuration, as well as a transmission signal that has been output from the transmis-

sion electrode and leaked into the ground electrode efficiently flowing into the via conductors connected along edge portions of the ground electrode which surround at least three sides of the transmission electrode, the distance along the edge portions of the ground electrode from the edge portion of the ground electrode close to the transmission electrode to the edge portion of the ground electrode close to the reception electrode becomes longer and therefore a transmission signal that has leaked into the ground electrode is prevented from traveling along an edge portion of the ground electrode toward the reception electrode side with certainty.

According to various preferred embodiments of the present invention, even if a transmission signal output from a transmission electrode of a mounting substrate to a transmission terminal of a splitter leaks into a ground electrode, the transmission signal that has leaked into the ground electrode flows into via conductors that are connected along an edge portion of the ground electrode close to the transmission electrode and therefore the transmission signal that has been output from the transmission electrode and leaked into the ground electrode is prevented from traveling along an edge portion of the ground electrode toward the reception electrode side and therefore the characteristics of isolation of the transmission electrode and the reception electrode from each other are greatly improved, the transmission electrode and the reception electrode being provided on the mounting substrate on which the splitter is mounted.

The above and other elements, features, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a first preferred embodiment of a circuit module of the present invention.

FIG. **2** is a block diagram illustrating the internal configuration of the circuit module of FIG. **1**.

FIG. **3** is a plan view illustrating an example of the shapes of electrodes of a mounting substrate.

FIG. **4** is a plan view illustrating an example of the shapes of electrodes of a mounting substrate in a second preferred embodiment of the present invention.

FIG. **5** is a plan view illustrating an example of the shapes of electrodes of a mounting substrate in a third preferred embodiment of the present invention.

FIG. **6** is a plan view illustrating an example of the shapes of electrodes of a mounting substrate in a fourth preferred embodiment of the present invention.

FIG. **7** illustrates an example of a splitter of the related art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Preferred Embodiment

Description will be given of a first preferred embodiment of a circuit module that includes a splitter (duplexer) of the present invention while referring to FIGS. **1** to **3**. FIG. **1** illustrates the first preferred embodiment of the circuit module of the present invention. FIG. **2** is a block diagram illustrating the internal configuration of the circuit module of FIG. **1**. FIG. **3** is a plan view illustrating an example of the shapes of electrodes of a mounting substrate.

A circuit module **1** illustrated in FIG. **1** is mounted on a motherboard MB included in a mobile communication terminal such as a cellular phone or a mobile information terminal, and, in this preferred embodiment, includes a mounting substrate **2**, a splitter **10**, and various components **3** such as a switch IC, a filter, a resistor, a capacitor and a coil, and preferably is a high-frequency antenna switch module, for example. In addition, the splitter **10** and the components **3** are mounted on electrodes provided on a mounting surface **2***a* of the mounting substrate **2** and are electrically connected to a plurality of mounting electrodes **6** located on a back surface of the mounting substrate **2** via an internal wiring pattern **5** provided inside the mounting substrate **2**. The circuit module **1** is mounted on the motherboard MB such that the circuit module **1** is connected to various signal lines that the motherboard MB is equipped with such as an antenna line ANT, a ground line GND, a transmission signal line Tx and a reception signal line Rx, and a power supply line, and input and output of transmission and reception signals between the motherboard MB and the circuit module **1** is performed.

The mounting substrate **2**, in this preferred embodiment, preferably is an integrated ceramic multilayer body formed by stacking a plurality of dielectric layers defined by ceramic green sheets on top of one another and then firing the stacked dielectric layers. The internal wiring pattern **5** is preferably provided by appropriately forming via conductors and electrode patterns in and on the dielectric layers.

That is, the ceramic green sheets that define the dielectric layers are fabricated by making a slurry, which is obtained by mixing a mixed powder of, for example, alumina and glass with an organic binder, a solvent and so forth, into sheets with a film formation apparatus and are formed so as to be capable of being subjected to so-called low-temperature firing, that is, at a low temperature of around 1000° C., for example. The dielectric layers are preferably formed by forming via conductors to provide connections between the layers by forming, by, for example, laser processing, via holes in the ceramic green sheets, which have been cut into a predetermined shape, filling the formed via holes with a conductive paste including for example Ag or Cu, and performing via fill plating, and forming various electrode patterns by printing a conductive paste.

The internal wiring pattern **5** is preferably formed by providing electrode patterns and via conductors on and in the dielectric layers, the electrode patterns and the via conductors to electrically connect the splitter **10** and the various components **3**, which are mounted in the circuit module **1**, to the mounting electrodes **6**. At this time, circuit elements such as capacitors and coils are formed by the electrode patterns and via conductors that form the internal wiring pattern **5** and a filter circuit and a matching circuit and so forth may be formed by the circuit elements such as capacitors and coils formed by the electrode patterns and via conductors, for example.

The splitter **10** preferably is used to separate transmission signals and reception signals with different frequencies from each other. As illustrated in FIG. **2**, the splitter **10** includes a transmission filter **11** and a reception filter **12** with different pass bands for a high-frequency signal. The transmission filter **11** and the reception filter **12** each preferably include a surface acoustic wave (SAW) filter device and in this preferred embodiment, a balanced output type reception filter **12** is preferably provided. Provided that it has function of allowing a signal of a certain band to pass therethrough, any device such as a dielectric filter or a BAW filter device may be used as the transmission filter **11** and the reception filter **12**, for example.

In addition, the splitter **10** includes a transmission terminal **13** to allow input to the transmission filter **11**, reception terminals **14** to allow output from the reception filter **12**, a

common terminal **15** (antenna terminal) that is connected to the output side of the transmission filter **11** and the input side of the reception filter **12**, and a ground terminal **16**, and the splitter **10** is connected to a transmission electrode **21**, reception electrodes **22**, a common electrode **23** and a ground electrode **24** provided on the mounting substrate **2**.

In this preferred embodiment, the transmission filter **11** and the reception filter **12** of the splitter **10** preferably are defined by SAW filter devices, but, instead of SAW filter devices, the transmission filter **11** and the reception filter **12** may be defined by connecting, for example, a plurality of resonators and coils together or the transmission filter **11** and the reception filter **12** may be any kind of device such as a dielectric filter or a BAW filter device provided that a transmission signal and a reception signal having different frequencies can be separated with certainty. In addition, it is sufficient that a typical apparatus that includes the transmission filter **11** and the reception filter **12** be adopted as the splitter **10** and since the structure and operation of such an apparatus are widely known, detailed description of the structure and operation of the splitter **10** will be omitted.

Next, with reference to FIG. **3**, examples of the shapes of the transmission electrode **21**, the reception electrodes **22**, the common electrode **23** and the ground electrode **24** provided on the mounting substrate **2** will be described.

As illustrated in FIG. **3**, in this preferred embodiment, the transmission electrode **21**, the reception electrodes **22** and the common electrode **23** are preferably provided by rectangular or substantially rectangular lands on the mounting surface **2***a* of the uppermost layer of the plurality of dielectric layers of the mounting substrate **2**. In addition, the ground electrode **24** is provided on the surface of a dielectric layer one layer below the dielectric layer including the mounting surface **2***a* and the ground electrode **24** is arranged between the transmission electrode **21** and the reception electrodes **22** when viewed in plan.

In addition, in this preferred embodiment, the transmission electrode **21** and the reception electrodes **22** are preferably provided in the vicinity of an edge **2***b* of the mounting surface **2***a* of the mounting substrate **2** and an end portion of the ground electrode **24** on the edge **2***b* side extends in both directions along the edge **2***b* so as to be T-shaped or substantially T-shaped when viewed in plan such that the ground electrode **24** is arranged between the edge **2***b* and the transmission electrode **21** and the reception electrodes **22**. In addition, the ground electrode **24** surrounds three sides of each of the transmission electrode **21**, the reception electrodes **22** and the common electrode **23** when viewed in plan. That is, in this preferred embodiment, the ground electrode **24** preferably includes a rectangular or substantially rectangular cut-out portion provided in each of three sides of its rectangular or substantially rectangular shape and the transmission electrode **21**, the reception electrodes **22** and the common electrode **23** are arranged in the three rectangular or substantially rectangular cut-out portions provided in the ground electrode **24** when viewed in plan.

In addition, the ground electrode **24** is connected to a mounting electrode **6**, which is connected to the ground line GND of the motherboard MB, by being connected to a plurality of via conductors **25** of the internal wiring pattern **5**. In this preferred embodiment, in particular, the plurality of via conductors **25** are connected along edge portions of the ground electrode **24** that are close to the transmission electrode **21** when viewed in plan. In addition, in this preferred embodiment, the plurality of via conductors **25** are connected along the edge portions of the ground electrode **24** from an edge portion of the ground electrode **24** that is close to the transmission electrode **21** to an edge portion of the ground electrode **24** close to the reception electrodes **22**.

In FIG. **3**, for ease of description, only the transmission electrode **21**, the reception electrodes **22**, the common electrode **23**, the ground electrode **24**, and the via conductors **25** connected to the ground electrode **24** are illustrated and illustration of other electrodes and via conductors **25** is omitted. In addition, in FIG. **3**, the ground electrode **24** and the via conductors **25** provided inside the mounting substrate **2** are illustrated with solid lines, and the mounting position of the splitter **10** on the mounting surface **2***a* is illustrated with broken lines in the same figure. In addition, the ground terminal **16** of the splitter **10** is connected to a mounting electrode provided on the mounting surface **2***a* and the ground electrode **24** through a via conductor connected to that electrode (not illustrated). FIGS. **4** to **6** used in description given below show similar illustrations to FIG. **3** and therefore description thereof is omitted hereafter.

Next, an outline of a non-limiting example of a method of manufacturing the circuit module **1** of FIG. **1** will be described.

First, ceramic green sheets for forming the dielectric layers constituting the mounting substrate **2** are prepared as follows. The via conductors **25** to provide connections between layers are formed by forming via holes using, for example, a laser in ceramic green sheets, then filling the insides of the via holes with a conductive paste and then performing via fill plating, then, electrode patterns such as the transmission electrode **21**, the reception electrodes **22**, the common electrode **23** and the ground electrode **24** are printed using a conductive paste. Electrode patterns such as the via conductors **25**, the transmission electrode **21**, the reception electrodes **22**, the common electrode **23** and the ground electrode **24** are provided on the ceramic green sheets in a plurality in order to make it possible to form a large number of mounting substrates **2** in one go.

Next, the dielectric layers are stacked on top of one another to form a multilayer body. Grooves, which will be used to divide the multilayer body into individual mounting substrates **2** after firing, are formed so as to enclose regions corresponding to the individual mounting substrates **2**. Next, an agglomeration of mounting substrates **2** is formed by subjecting the multilayer body to low-temperature firing.

An agglomeration of circuit modules **1** is formed by, prior to dividing the multilayer body into individual mounting substrates **2**, mounting splitters **10** and components **3** on the mounting surfaces **2***a* of the agglomeration of the mounting substrates **2** and providing a molded layer (not illustrated) on each of the mounting substrates **2** by covering the mounting surfaces **2***a* of the agglomeration of the mounting substrates **2** on which the splitters **10** and the components **3** are mounted with molding resin and thermally curing the molding resin. The circuit modules **1** are completed by dividing the agglomeration of circuit modules **1** into individual pieces.

In the thus-formed circuit module **1**, a transmission signal output from the transmission signal line Tx of the mother substrate MB to the transmission terminal **13** of the splitter **10** via a mounting electrode **6** and the internal wiring pattern **5** is input to the transmission filter **11** and subjected to predetermined filter processing, output to the mounting substrate **2** side from the common terminal **15**, and output to the antenna line ANT of the motherboard MB via the internal wiring pattern **5** (matching circuit) and a mounting electrode **6**. In addition, a reception signal that is input to the common terminal **15** of the splitter **10** from the antenna line ANT of the motherboard MB via a mounting electrode **6** and the internal wiring pattern **5** (matching circuit) is input to the reception

filter **12** and subjected to predetermined filter processing, output to the mounting substrate **2** side from the reception terminals **14** and is output to the reception signal line Rx of the motherboard MB via the internal wiring pattern **5** and a mounting electrode **6**.

The circuit module **1**, which includes the mounting substrate **2**, in which the internal wiring pattern **5** is provided, the splitter **10**, the components **3** and the molded layer, is not limited to being manufactured by the above-described method and may be formed by any general widely known method, and the mounting substrate **2** can be a printed board, an LTCC, an alumina-based substrate, a glass substrate, a composite material substrate, a single-layer substrate, a multilayer substrate and so on using for example a resin, a ceramic or a polymer material, and the mounting substrate **2** may be formed by choosing the most appropriate material in accordance with the intended use of the circuit module **1**, for example.

In addition, in this preferred embodiment, a matching circuit is preferably defined by the internal wiring pattern **5**, but a matching circuit may instead include components **3** such as chip coils mounted on the mounting surface **2***a* of the mounting substrate **2**, for example.

As described above, in this preferred embodiment, the splitter **10** includes the transmission terminal **13** that allows input to the transmission filter **11**, the reception terminals **14** that allow output from the reception filter **12** and the ground terminal **16**, and the transmission electrode **21**, which is connected to the transmission terminal **13** of the splitter **10**, the reception electrodes **22**, which are connected to the reception terminals **14** of the splitter **10**, and the ground electrode **24**, which is arranged between the transmission electrode **21** and the reception electrodes **22** when viewed in plan and is connected to the ground terminal **16** of the splitter **10**, are provided on the mounting substrate **2** on which the splitter **10** is mounted. In addition, a plurality of via conductors **25** are connected to the ground electrode **24** of the mounting substrate **2** along an edge portion of the ground electrode **24** close to the transmission electrode **21** when viewed in plan.

Therefore, even if a transmission signal output from the transmission electrode **21** of the mounting substrate **2** to the transmission terminal **13** of the splitter **10** leaks into the ground electrode **24**, since the transmission signal that has leaked into the ground electrode **24** flows into the via conductors **25**, which are connected along an edge portion of the ground electrode **24** close to the transmission electrode **21** and are connected to the ground line GND of the motherboard MB, the transmission signal that has been output from the transmission electrode **21** and leaked into the ground electrode **24** is prevented from traveling along an edge portion of the ground electrode **24** toward the reception electrodes **22** side and the transmission electrode **21** and the reception electrodes **22** are prevented from becoming electrically coupled with each other via the transmission signal that has leaked into the ground electrode **24** and therefore, improvement of the characteristics of isolation of the transmission electrode **21** and the reception electrodes **22** from each other is achieved, the transmission electrode **21** and the reception electrodes **22** being provided on the mounting substrate **2** on which the splitter **10** is mounted.

In addition, since the plurality of via conductors **25** preferably are connected to the ground electrode **24** along edge portions of the ground electrode **24** from an edge portion of the ground electrode **24** close to the transmission electrode **21** to an edge portion of the ground electrode **24** close to the reception electrodes **22** when viewed in plan, a transmission signal, which has been output from the transmission electrode **21** and leaked into the ground electrode **24**, is more efficiently prevented from traveling along the edge portion of the ground electrode **24** toward the reception electrodes **22** side by more efficiently allowing the transmission signal to flow into the plurality of via conductors **25** that are connected along the edge portions of the ground electrode **24**, and therefore the characteristics of isolation of the transmission electrode **21** and the reception electrodes **22** from each other are further improved, the transmission electrode **21** and the reception electrodes **22** being provided on the mounting substrate **2** on which the splitter **10** is mounted.

In addition, the transmission electrodes **21** and the reception electrodes **22** are provided in the vicinity of the edge **2***b* of the mounting surface **2***a* of the mounting substrate **2**, such that the circuit module **1** is significantly reduced in size by arranging the splitter **10** close to the edge of the mounting substrate **2**. However, since the ground electrode **24** is provided between the edge **2***b* of the mounting substrate **2** and the transmission electrode **21** and the reception electrodes **22** when viewed in plan, a transmission signal that has been output from the transmission electrode **21** and has leaked into the ground electrode **24** flows into the plurality of via conductors **25** connected along the edge portions of the ground electrode **24** provided between the edge **2***b* of the mounting substrate **2** and the transmission electrode **21**, in particular those on the transmission electrode **21** side, and the transmission signal that has leaked into the ground electrode **24** is prevented from traveling along an edge portion of the ground electrode **24** toward the reception electrodes **22** side. As a result, good characteristics of isolation of the transmission electrode **21** and the reception electrodes **22** from each other are maintained even when the space between the transmission electrode **21** and the reception electrodes **22** provided on the mounting substrate **2** has become smaller due to the circuit module **1** being reduced in size.

In addition, since the transmission electrode **21**, the reception electrodes **22** and the common electrode **23** are preferably provided by rectangular or substantially rectangular lands on the mounting surface **2***a* of the substrate **2** and the ground electrode **24** surrounds at least three sides of the transmission electrode **21**, the reception electrodes **22** and the common electrode **23** when viewed in plan, since a transmission signal that has been output from the transmission electrode **21** and that has leaked into the ground electrode **24** efficiently flows into the via conductors **25** connected along the edge portion of the ground electrode **24** that surrounds at least three sides of the transmission electrode **21** and the distance from the edge portion of the ground electrode **24** that is close to the transmission electrode **21** to the edge portion of the ground electrode **24** that is close to the reception electrodes **22** when viewed in plan along the edge portions of the ground electrode **24** is long, a transmission signal that has leaked into the ground electrode **24** is prevented with certainty from traveling along an edge portion of the ground electrode **24** toward the reception electrodes **22** side.

Second Preferred Embodiment

Next, a second preferred embodiment of the present invention will be described with reference to FIG. **4**. FIG. **4** is a plan view illustrating an example of the shapes of electrodes of a mounting substrate in a second preferred embodiment of the present invention. This preferred embodiment differs from the above-described first preferred embodiment in that, as illustrated in FIG. **4**, an extended portion **24***a* (corresponding to a "first extended portion"), which is provided to as to extend toward the outside of the splitter **10**, is provided on the

transmission electrode **21** and reception electrodes **22** side of the ground electrode **24** when viewed in plan. Other elements of the configuration are preferably the same as in the first preferred embodiment described above and therefore the same symbols are used and description thereof is omitted.

With this configuration, since the ground electrode **24** includes the extended portion **24***a* provided so as to extend toward the outside of the splitter **10** when viewed in plan, the distance from the edge portion of the ground electrode **24** near to the transmission electrode **21** to the edge portion of the ground electrode **24** near to the reception electrodes **22** along the edge portions of the ground electrode **24** becomes longer and therefore a transmission signal that has been output from the transmission electrode **21** and leaked into the ground electrode **24** is prevented from traveling along an edge portion of the ground electrode **24** toward the reception electrodes **22** side.

In addition, the extended portion **24***a* of the ground electrode **24** may also extend in at least one of directions toward the transmission electrode **21** and the reception electrodes **22** from an end portion of the extended portion **24***a* (corresponding to "second extended portion") such that the ground electrode **24** is arranged so as to be close to at least two sides of the rectangular or substantially rectangular shapes of the transmission electrode **21** or the reception electrodes **22**. With this configuration, since the distance from the edge portion of the ground electrode **24** near to the transmission electrode **21** to the edge portion of the ground electrode **24** near to the reception electrodes **22** along the edge portions of the ground electrode **24** when viewed in plan becomes even longer, a transmission signal that has been output from the transmission electrode **21** and leaked into the ground electrode **24** is prevented from traveling along an edge portion of the ground electrode **24** toward the reception electrodes **22** side with even more certainty.

Third Preferred Embodiment

Next, a third preferred embodiment of the present invention will be described with reference to FIG. **5**. FIG. **5** is a plan view illustrating an example of the shapes of electrodes of a mounting substrate in the third preferred embodiment of the present invention. This preferred embodiment differs from the above-described first preferred embodiment in that, as illustrated in FIG. **5**, two splitters **10** and **10***a* are mounted on the mounting surface **2***a* of the mounting substrate **2**, a transmission electrode **21***a*, reception electrodes **22***a* and a common electrode **23***a*, on which the splitter **10***a* is mounted, are further provided on the mounting surface **2***a*, and the ground electrode **24** is arranged over a large area so as to be located between the transmission electrodes **21** and **21***a* and the reception electrodes **22** and **22***a*. Other elements and arrangements of the configuration are preferably the same as in the first preferred embodiment described above and therefore the same symbols are used and description thereof is omitted.

With this configuration, the same advantageous effects as with the above-described first preferred embodiment are attained.

Fourth Preferred Embodiment

Next, a fourth preferred embodiment of the present invention will be described with reference to FIG. **6**. FIG. **6** is a plan view illustrating an example of the shapes of electrodes of a mounting substrate in a fourth preferred embodiment of the present invention. This preferred embodiment differs from the above-described third preferred embodiment in that, as illustrated in FIG. **6**, the transmission electrode **21** and the reception electrodes **22** that mount the splitter **10** are arranged in a central portion of the ground electrode **24** in the up/down direction in the figure and the common electrode **23** is arranged on the upper edge side of the ground electrode **24**. Other elements and arrangements of the configuration are preferably the same as in the third preferred embodiment described above and therefore the same symbols are used and description thereof is omitted. In FIG. **6**, only via conductors **25** connected along edge portions of the ground electrode **24** close to the transmission electrodes **21** and **21***a* are illustrated and illustration of the other via conductors **25** is omitted.

With this configuration, the distance from the edge portion of the ground electrode **24** near to the transmission electrodes **21** and **21***a* to the edge portion of the ground electrode **24** near to the reception electrodes **22** and **22***a* along the edge portions of the ground electrode **24** when viewed in plan becomes longer and the same advantageous effects as in the above-described first preferred embodiment are attained.

The present invention is not limited to the above-described preferred embodiments and can be modified in various ways not described above so long as they do not depart from the gist of the present invention. For example, the ground electrode **24** may be arranged across a plurality of dielectric layers of the mounting substrate **2** and the individual portions of the ground electrode **24** may be connected to each other with a plurality of via conductors **25**.

With this configuration, since the individual portions of the ground electrode **24**, which is provided across a plurality of layers in the mounting substrate **2**, are connected to each other with the via conductors **25**, transmission signals that have been output from the transmission electrodes **21** and **21***a* and leaked into the ground electrode **24** more efficiently flow into the plurality of via conductors **25** connected along edge portions of the ground electrode **24** close to the transmission electrodes **21** and **21***a* when viewed in plan and therefore, a transmission signal that has leaked into the ground electrode **24** can be more efficiently prevented from traveling along an edge portion of the ground electrode **24** toward the reception electrodes **22** and **22***a* side, and the characteristics of isolation of the transmission electrodes **21** and **21***a* and the reception electrodes **22** and **22***a* from each other are even more improved, the transmission electrodes **21** and **21***a* and the reception electrodes **22** and **22***a* being provided on the mounting substrate on which the splitters **10** and **10***a* are mounted.

In addition, the individual portions of the ground electrode **24** provided across a plurality of layers in the mounting substrate **2** may have the same shape, but transmission signals that have been output from the transmission electrodes **21** and **21***a* and leaked into the ground electrode **24** are efficiently guided into the plurality of via conductors **25** connected along the edge portions of the ground electrode **24** if at least the portions of the ground electrode **24** that are close to the transmission electrodes **21** and **21***a* have the same shape when viewed in plan.

In addition, the ground electrode **24** may at least surround the transmission electrodes **21** and **21***a* when viewed in plan. With this configuration, as well as transmission signals that have been output from the transmission electrodes **21** and **21***a* and leaked into the ground electrode **24** flowing into the via conductors **25** connected along the edge portions of the ground electrode **24** surrounding the transmission electrodes **21** and **21***a*, the transmission signals that have leaked into the ground electrode **24** are prevented from traveling along an edge portion of the ground electrode **24** toward the reception electrodes **22** and **22***a* side with certainty since the edge portions of the ground electrode **24** that surround the trans-

mission electrodes **21** and **21***a* and the edge portions of the ground electrode **24** that are close to the reception electrodes **22** and **22***a* are not connected to each other.

In addition, it is sufficient that a plurality of via conductors **25** be connected along at least the edge portions of the ground electrode **24** that are close to the transmission electrodes **21** and **21***a* when viewed in plan and the ground electrode **24** may be provided on the mounting surface **2***a* of the mounting substrate **2**.

In addition, the shapes of the transmission electrodes **21** and **21***a*, the reception electrodes **22** and **22***a* and the common electrodes **23** and **23***a* provided on the mounting surface **2***a* of the mounting substrate **2** are not limited to being rectangular or substantially rectangular shapes and may be any shape such as a circular or substantially circular shape so long as the splitters **10** and **10***a* can be mounted, and the ground electrode **24** need not necessarily be arranged so as to surround the rectangular or substantially rectangular shaped transmission electrodes **21** and **21***a*, reception electrodes **22** and **22***a* and the common electrodes **23** and **23***a* from at least three sides.

Preferred embodiments of the present invention can be widely applied to circuit modules that include a splitter including a transmission filter and a reception filter with different pass bands from each other.

While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. A circuit module comprising:

a splitter that includes a transmission filter and a reception filter with different pass bands from each other; and

a mounting substrate on which the splitter is mounted; wherein

the splitter includes a transmission terminal that allows input to the transmission filter, a reception terminal that allows output from the reception filter, and a ground terminal;

the mounting substrate includes a transmission electrode that is connected to the transmission terminal, a reception electrode that is connected to the reception terminal, and a ground electrode that is arranged between the transmission electrode and the reception electrode when viewed in plan and is connected to the ground terminal;

a plurality of via conductors are connected to the ground electrode along an edge portion of the ground electrode that is close to the transmission electrode when viewed in plan; and

the mounting substrate includes a plurality of dielectric layers, and a layer of the plurality of dielectric layers at which the ground electrode is provided is different from a layer of the plurality of dielectric layers at which the transmission electrode, the reception electrode, and the common electrode are provided.

2. The circuit module according to claim **1**, wherein the plurality of via conductors are connected to the ground electrode along edge portions of the ground electrode from an edge portion of the ground electrode close to the transmission electrode to an edge portion of the ground electrode close to the reception electrode when viewed in plan.

3. The circuit module according to claim **1**, wherein the transmission electrode and the reception electrode are provided adjacent to or in an area of an edge of a mounting surface of the mounting substrate and the ground electrode is provided between that edge and the transmission electrode when viewed in plan.

4. The circuit module according to claim **1**, wherein the ground electrode is provided across a plurality of layers of the mounting substrate and individual portions of the ground electrode are connected to each other through the via conductors.

5. The circuit module according to claim **4**, wherein the individual portions of the ground electrode provided across the plurality of layers in the mounting substrate have the same shape.

6. The circuit module according to claim **1**, wherein the ground electrode includes a first extended portion that extends towards an outside of the splitter when viewed in plan.

7. The circuit module according to claim **6**, wherein the ground electrode further includes a second extended portion that extends from an end portion of the first extended portion in at least one of a direction toward the transmission electrode and a direction toward the reception electrode.

8. The circuit module according to claim **1**, wherein the ground electrode surrounds at least the transmission electrode when viewed in plan.

9. The circuit module according to claim **1**, wherein at least one of the transmission electrode and the reception electrode includes a rectangular or substantially rectangular land on a mounting surface of the mounting substrate and the ground electrode surrounds at least three sides of the transmission electrode or the reception electrode when viewed in plan.

10. The circuit module according to claim **1**, wherein

the splitter includes a common terminal that is connected to an output side of the transmission filter and an input side of the reception filter;

the transmission electrode, the reception electrode, and a common electrode, which is connected to the common terminal, include rectangular or substantially rectangular lands located on the mounting surface of the mounting substrate; and

the ground electrode surrounds at least three sides of each of the transmission electrode, the reception electrode and the common electrode when viewed in plan.

11. The circuit module according to claim **10**, wherein a shape of the common electrode is one of rectangular, substantially rectangular, circular and substantially circular.

12. The circuit module according to claim **1**, wherein the circuit module is a high-frequency antenna switch module.

13. The circuit module according to claim **1**, wherein each of the transmission filter and the reception filter includes at least one of a surface acoustic wave device, a dielectric filer and a bulk acoustic wave device.

14. The circuit module according to claim **1**, wherein the splitter is a first splitter, the circuit module including a second splitter mounted on the substrate.

15. The circuit module according to claim **14**, wherein the ground electrode is located between the transmission electrodes and the reception electrodes of the first and second splitters.

16. The circuit module according to claim **1**, wherein

the splitter includes a common electrode that is connected to an output side of the transmission filter and an input side of the reception filter; and

the transmission electrode and the reception electrode are arranged in a central portion of the ground electrode and the common electrode is arranged on an upper edge side of the ground electrode.

17. The circuit module according to claim 1, wherein a shape of each of the transmission electrode and the reception electrode is one of rectangular, substantially rectangular, circular and substantially circular.

18. A mobile communication terminal comprising the circuit module according to claim 1.

19. A mobile information terminal comprising the circuit module according to claim 1.

20. The circuit module according to claim 1, wherein the transmission electrode and the reception electrode are provided at an uppermost layer of the plurality of dielectric layers, and the layer at which the ground electrode is provided is one layer below the uppermost layer.

21. The circuit module according to claim 1, wherein an end portion of the ground electrode on an edge side thereof extends in both directions along an edge of the mounting substrate so as to be substantially T-shaped, such that the ground electrode is arranged between the edge of the mounting substrate and the transmission and reception electrodes.

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